

**Prepared Statement  
of  
Richard H. Truly  
Director, National Renewable Energy Laboratory  
Before the  
Committee on Agriculture  
Subcommittee on Department Operations, Oversight, Nutrition and Forestry  
March 15, 2004**

---

Mr. Chairman and members of the Committee, I'm Richard Truly, director of the National Renewable Energy Laboratory (NREL) in Golden, Colorado. NREL is the nation's premier laboratory for research and development of renewable energy technologies and is a leading laboratory for research and development of energy efficiency technologies. NREL is home of the National Bioenergy Center and the National Wind Technology Center and is managed for the Department of Energy by Midwest Research Institute and Battelle.

I appreciate the opportunity to testify today about some of the new and innovative ways NREL and its partners are putting renewable energy to work for rural America. To address the Committee's question about the role of renewable energy and its impact on the farm economy, I will focus on one of the key renewable energy technologies with significant application to the farm economy and rural America - biomass energy. I will also review the status of NREL's research in the area of wind energy, another technology with significant benefits to the farm economy and rural America.

### **Introduction**

DOE's Office of Energy Efficiency and Renewable Energy (EERE) has long sponsored research at NREL and other national laboratories that has helped to bring clean, affordable energy technologies to Americans and to people all over the world. New developments in these technologies provide ample evidence of the progress that has been made, but even more importantly, they have offered a picture of what can be achieved in the future.

I want to focus on two of those programs that provide significant benefits to rural America - biomass and wind – and share with you some of the key technology opportunities and challenges we face in these areas.

### **Biomass: A Unique Resource**

In the realm of renewable energy, biomass - organic materials such as agricultural crops, plants, trees, grasses and wastes - presents us with unique opportunities and tremendous challenges. All renewable energy technologies offer the ability to directly or indirectly

capture the sun's energy. Biomass, however, is the only renewable technology that can use the sun's energy to capture carbon dioxide (CO<sub>2</sub>), a major greenhouse gas in the atmosphere, and turn it into organic (carbon-based) molecules that we can use to produce fuels and chemicals, making this renewable resource uniquely indispensable as our supply of fossil fuel diminishes.

Unlike other sources of renewable energy, biomass (and the land that is dedicated to its production) serves as the source of all our food, feed and natural fiber. Any sustainable scenario for the use of biomass as a renewable energy source must, therefore, balance all of these high priority needs, which are uniquely met by biomass. That will be true before and after we run out of fossil fuels. No other renewable energy source faces this added challenge.

Biomass is also unique in that it can take advantage of the natural recycling process for atmospheric CO<sub>2</sub> associated with photosynthesis. CO<sub>2</sub> released by the combustion of bio-based fuels, for example, is recycled back into new plant matter. The net effect is that, while the use of bio-based fuels results in CO<sub>2</sub>, it adds no net CO<sub>2</sub> to the atmosphere.

### **There's Plenty of Biomass**

The good news is that there are already plentiful supplies of biomass, and there are many opportunities to substantially increase our ability to harvest biomass and recycle CO<sub>2</sub> through the biomass-CO<sub>2</sub> cycle. Researchers at DOE's national labs have already developed sustainable scenarios that show how biomass resources produced within the U.S. could replace a significant amount of our gasoline usage. Achieving such a target will likely require significant change in agricultural and forestry practices, and it is certainly not going to happen overnight.

In the future, biomass can combine with other renewable energy sources, especially wind and solar, to play a steadily increasing role in supplying electrical power and will someday be a critical source of renewable hydrogen. We cannot be certain what percentage of our energy usage will need to come from biomass. And, just as the timeframe for exhausting petroleum, natural gas, and coal reserves is uncertain, so is the timeframe for transitioning to alternative energy sources. In fact, it seems likely to many that the transition to alternative energy will be driven more by environmental and energy security concerns than a depletion of fossil energy resources.

### **The Multiple Pathways for Biomass Conversion**

DOE's Biomass Program includes research on a number of different technologies for converting biomass into fuels, chemicals and electricity. These technology pathways fall into two categories—thermal and biological processes. The simplest thermal process for biomass conversion is combustion to produce heat and electricity. More sophisticated thermal processes include gasification and pyrolysis technologies that use heat to break down biomass into gaseous and liquid products that can be further processed into fuels and chemicals. On the biological side, recovery and fermentation of the sugars contained

in biomass—processes that are as old as the brewing industry—can be used to produce an array of fuels and products, most notably ethanol. Anaerobic digestion is another very well established biological pathway that takes advantage of natural microbial processes that can convert most organic matter into methane—the main component of natural gas.

### **Building on the Success of Fuel Ethanol from Corn Grain**

One of the most important currently available bioenergy technologies is corn grain ethanol. Fuel ethanol represents a major success for DOE and USDA, as part of our efforts to develop viable near-term alternatives to gasoline in our almost exclusively petroleum-dependent transportation sector. The first ethanol plants built in the late 1970s were costly and energy-intensive, sparking an early debate about whether it made good “energy sense” to replace gasoline with ethanol. Today’s ethanol process is considerably more cost effective. Most experts now acknowledge that fuel ethanol offers real energy savings.<sup>1</sup> Minnesota and Iowa have both shared in the outstanding growth in corn grain ethanol plants over the past two and half decades. With over 3 billion gallons of annual production capacity in the U.S. today, and an annual growth rate of about 30%, corn grain ethanol is clearly becoming a critical source of renewable liquid transportation fuel. One of the important benefits of ethanol is the manner in which it can be blended with gasoline and used in today’s dispensing systems and the internal combustion engines used in automobiles.

### **Lignocellulosic Biomass is Critical to Future Large-Scale Replacement of Petroleum**

When we began promoting the production and use of ethanol made from corn grain in the late 1970s, we saw this industry as the home for future technology that would allow us to move beyond corn grain to include other forms and sources of biomass, commonly referred to as lignocellulosic biomass. Lignocellulosic biomass is “everything else” in biomass beyond the simple sugars, starch and protein that are more valuable as inputs to our food supply.

There is an enormous amount of available lignocellulosic biomass. It comes in a variety of different forms, including the municipal solid waste now being sent to landfills, residues left on the farm after the harvesting of corn and wheat, forest residues, and in the future, a new generation of dedicated energy crops. The latter includes a new generation of perennial grasses and fast-growing trees that have been developed jointly by researchers at DOE and USDA laboratories, in partnership with industry and universities. For biomass to significantly reduce petroleum usage, we need to reduce the cost of producing ethanol from the much more plentiful lignocellulosic forms of biomass.

---

<sup>1</sup> Shapouri, H., J. Duffield, and M. Wang. 2002. *The energy balance of corn ethanol: An update*. AER Report No. 813. Washington, D.C.: U.S. Department of Agriculture, Office of the Chief Economist, Office of Energy Policy and New Uses.

## **Lignocellulosic Biomass Ability to Reduce Fossil Energy Use**

In an ideal world, every Btu of ethanol burned in a car would completely displace a Btu of fossil fuel. However, the production, transport and conversion of biomass require fossil energy inputs. We measure the effectiveness of ethanol's ability to replace fossil energy by calculating its "Fossil Energy Replacement Ratio" (FERR). It is defined as the ratio of the useful energy produced in the form of fuel grade ethanol per unit of fossil energy consumed in the production of the fuel. In order to be effective at reducing fossil energy use, a fuel must have a ratio greater than one, and the higher the ratio the better. While fuel ethanol from corn grain has a ratio of 1.3<sup>1</sup>, fuel ethanol made from the lignocellulosic biomass such as corn stover has a ratio of 5.1.<sup>2</sup> This means that, for lignocellulosic biomass, one Btu of fossil energy can yield 5.1 Btu of fuel ethanol.

## **The Economic Goals**

So, why aren't we producing ethanol from lignocellulosic biomass today? Simply put, the research is not complete and the cost is too high. If we were to build a facility today for converting lignocellulosic biomass to ethanol, it would produce ethanol at twice the price of one of today's existing corn grain ethanol facilities. However, through research, we are making steady progress to reduce the cost. Just a few years ago the cost was 4 to 5 times too high. The focus of our research is to make this conversion competitive with corn ethanol within the next 6 years, and in the long run, our goal is make fuel ethanol competitive with gasoline.

Congress, through DOE's Office of the Biomass Program (OBP), has, for the past five years, invested \$90 to 110 million per year in research and development aimed at the goal of introducing new biomass-based alternatives to petroleum-derived transportation fuels. The largest portion of this annual investment is dedicated to the commercialization of ethanol made from lignocellulosic biomass. OBP, with support from NREL and other national laboratories, has developed technical plans detailing how a continued investment of this size could lead to commercial demonstration of ethanol and other biomass technologies by the end of the decade.

## **Overcoming Technical Barriers to a New Bioindustry: The Role of NREL and the National Bioenergy Center**

The Department of Energy created the National Bioenergy Center (NBC) in 2000 to foster the national development of technologies and capabilities for producing fuels, chemicals, and power from biomass. Working for the Office of the Biomass Program within EERE and headquartered at NREL, this virtual center coordinates the biomass research at other national laboratories and works with universities and industry partners.

---

<sup>2</sup> Sheehan, J., A. Aden, C. Riley, K. Paustian, K. Killian, J. Brenner, D. Lightle, M. Walsh, J. Cushman, and R. Nelson. 2002. *Is ethanol from corn stover sustainable? (draft)*. Golden, CO: National Renewable Energy Laboratory.

Together, the NBC and OBP have developed a comprehensive multi-year plan that outlines the major technical barriers and DOE's strategies for overcoming these barriers to make the production of biofuels from lignocellulosic biomass economical and attractive for investment by the private sector.

The major areas of the NBC's research include:

- **Resource assessment** - to better understand the full potential and availability of biomass, and develop strategies to maximize the yield of fuels after meeting the need for food and fiber.
- **Harvesting technology R&D** - to develop sustainable low-cost methods of harvesting agricultural crops in a single pass. The grain is harvested for food and the remainder of the plant is harvested for conversion to fuels, chemicals and power in a biorefinery. Some of the plant is left on the soil to maintain soil quality.
- **Transportation logistics** - to develop lower cost methods of handling and transporting biomass. Today, the cost of getting agricultural residues off the farm and transported to a biorefinery is a major contributor to the high cost of producing fuels from agricultural residues.
- **Conversion technology** - to reduce cost and improve yield of useful fuels, chemicals and power from biomass. This area of research represents the greatest area of effort by the DOE national laboratories. One focal point of this research is on pre-treating biomass to make it more susceptible to conversion technologies. Another focus is on reducing or overcoming the difficulty of biochemical conversion of cellulose to ethanol.
- **Products research** - to ensure high yields of quality fuels that can be blended with gasoline, diesel, or jet fuel and develop higher-value chemical co-products that can improve the economics of an integrated biorefinery.
- **Analytical studies** - to thoroughly assess and understand the economics of producing fuels, chemicals, and power from biomass. Analytical studies also include the life cycle assessments of various biomass conversion strategies to understand and quantify all the environmental aspects of bioenergy systems.
- **Measurement techniques** – to provide chemical and physical measurement methods and associated equipment needed by the emerging bioenergy industry to characterize biomass feedstocks.

### **Public-Private Partnerships**

DOE is working in partnership with the today's corn grain ethanol industry to develop the technology that will enable the creation of a new bioindustry. For example, DOE is

currently partnering with Broin and Abengoa—two major ethanol technology providers and ethanol producers—to increase the yield of ethanol from existing corn ethanol facilities. Both of these partnerships are intended to expand the feedstock range and conversion efficiency of the private partner's ethanol plants.

DOE is also partnering with existing chemical industry leaders such as Dupont and Dow Chemical to develop new opportunities for producing both fuels and chemicals from biomass. DuPont and DOE are working together with several other partners to develop what Dupont calls an Integrated Corn Biorefinery (ICBR.) The goal of this public/private partnership is to develop a biorefinery that can efficiently convert the starch in corn grain to a low-cost sugar as feedstock to make value-added chemicals, while using the remaining lignocellulosic parts of the corn plant to produce ethanol and power. The ethanol produced from these ICBR's would have a goal to be competitive at first with corn grain ethanol, and possibly with gasoline in the absence of a subsidy. When successful, Dupont's process design could be added onto existing corn ethanol facilities to dramatically improve the yield of ethanol and overall profitability of the facility.

Here in Minnesota, DOE is partnering with both large and small companies in the biomass area. Cargill is working with DOE on the development of a new chemical building-block produced from sugars. Cargill-Dow, another Minnesota Corporation and a joint venture formed by Cargill and Dow Chemical, is working with DOE and its labs to develop new biorefineries that use the corn plant (both the grain and the lignocellulosic fraction) to produce polylactic acid (PLA)—a unique and environmentally-friendly renewable polymer. Cargill-Dow has also constructed its first PLA facility in Blair, Nebraska. This facility produces PLA from the starch in corn while the technology focus is to utilize the remaining lignocellulosic components in the corn plant in the PLA production process.

DOE labs are also partnering with equipment manufacturers, Case New Holland and John Deere, to develop new harvesting equipment that would allow farmers to harvest the grain and straw at the same time. This technology is being developed for wheat and corn first, but the concept has broader applicability. In stakeholder meetings with farmers and equipment manufacturers, DOE has determined that single-pass harvesting technology could significantly reduce the cost of supplying biomass (wheat straw or corn stover) to a biorefinery.

With its plentiful biomass resources, Minnesota provides an excellent example of how rural America is well positioned to enjoy considerable economic growth, as renewable energy technologies become more cost competitive with petroleum.

Minnesota is a leader in the field of biofuels, and is home to more than a dozen ethanol plants, several first-of-a-kind biopower facilities, and an emerging biodiesel industry. District Energy, located in St. Paul, has constructed and is operating one of the world's largest and most innovative Combined Heat and Power (CHP) biomass facilities. Minnesota has also pioneered several early-stage exploratory projects with different energy crop concepts.

## **Wind Energy Benefits for the Rural Economy – A New Cash Crop**

There is another bright spot on the rural economic development horizon: wind energy. The wind industry contributes to the economies of 46 states, and the outlook for regional economic growth from wind energy is impressive. Wind energy projects provide new jobs, a new source of revenue to farmers and ranchers, and an increased local tax base for rural communities. And wind energy helps secure our energy future during uncertain times while reducing pollution emissions and offsetting the larger water consumption associated with fossil fuel central station power plants.

Wind energy offers rural landowners a new “cash crop”. Rural landowners who lease their land to wind developers typically receive about 2% to 4% of the gross annual turbine revenue. In southern Minnesota and northern Iowa, landowners receive annual payments from \$2,000 to more than \$4,000 per turbine, which can help compensate for a downturn in commodity prices.

## **Expanding Wind Energy in Rural America: The Low Wind Speed Turbine**

There is a recognized and important opportunity for broader use of wind energy in rural America. This new opportunity is based on the development of wind turbines that can efficiently operate in lower wind regimes.

Strong, frequent winds are ideal for generating electricity. The best resource areas are shown on maps incorporating wind speeds based on meteorological measurements and models. Annual average wind speed is used to calculate the energy in the wind blowing through a wind turbine's rotor per square meter of area, expressed as watts per square meter. Geographic areas as small as one square mile are assigned a wind power class from 1 to 7. State officials and developers use this information for wind development. Sites in wind power class 3 or higher are candidates for wind farm development.

Currently, utility-scale wind turbines can produce cost-competitive electricity on class 6 wind sites (average wind speeds of 16 miles per hour at 33 feet). However, as more sites are developed, easily accessible Class 6 sites are becoming rare. In addition, many Class 6 sites are located in remote areas that do not have easy access to transmission lines.

Class 4 wind sites (13 mph at 33 feet) cover vast areas of the Great Plains from central and northern Texas to the Canadian border. While the average distance of Class 6 sites from major load centers is 500 miles, Class 4 sites are significantly closer, with an average distance of 100 miles from load centers. Utility access to the Class 4 sites is more attractive and less costly, and Class 4 sites represent almost 20 times the developable wind resource of Class 6 sites.

DOE and its national laboratories, in partnership with our industry partners, are developing the next generation of wind turbine technology to produce competitively priced electricity in lower wind regimes and thereby expand the use of wind energy to

even greater expanses of America. The goal of DOE's Low Wind Speed Turbine (LWST) project is to reduce the cost of energy from large wind systems. The strategy for the LWST project, developed in cooperation with industry, includes:

- Developing public/private partnerships to support continuing innovation.
- Aligning program research and testing activities to support public/private partnerships.
- Guiding portfolio planning and technology transfer with applied systems integration activities.
- Performing program evaluations regularly using performance-based management techniques to provide a strong analytical basis for performance criteria, periodic review, and adjustment.

### **Conclusions**

Today, biomass is making the largest contribution of renewable resources to the nation's energy needs, currently supplying about 3% of all the energy consumed in the U.S. When combined with the advantages of wind energy, the energy and economic future looks bright for rural America.

The shared vision of DOE and NREL is that biomass will supply an increasing percentage of U.S. energy needs. Our belief is that over the next 10-20 years, biomass will be used to supply increasing amounts of ethanol, biodiesel, biobased chemicals, and power. Future biorefineries will maximize the value of biomass by producing the optimum slate of products, in much the same way that petroleum refineries maximize the value of crude oil by producing an array of petroleum products.

Beyond biomass, wind energy is becoming the other new "cash crop" for rural America. The challenge is to bring wind power to more of rural America by bringing the next generation of wind technology capable of producing competitively priced electricity to farms and ranches in Minnesota and other states.

Ultimately, we expect that clean burning hydrogen and hydrogen fuel cell technology will begin to become cost effective, and all renewables, including biomass, wind, and solar, will eventually be used to produce hydrogen as it becomes the energy currency of the latter half of the 21<sup>st</sup> century. That's good news for rural America and for the rest of the country.

Mr. Chairman, that concludes my prepared statement. I would be happy to answer any questions from members of the subcommittee.